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EA-6B MISSION PLANNING AND ROUTE OPTIMIZATION PROGRAM

Paul Odell

NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

EA-6B MISSION PLANNING AND ROUTE OPTIMIZATION PROGRAM

by

Paul Odell Jr.

March 1978

Thesis Advisor: H. A. Titus

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The EA-6B Mission Planning and Route Optimization Program was created for use with the WANG 2200 computer system by aircrewmen deployed on board aircraft carriers. It is an interactive computer program designed to increase the effectiveness and efficiency of the mission planning process, while reducing the time involved in this evolution. These goals are accomplished through the use of two schemes. First is an

automation of the clerical planning tasks of retrieval, listing, and plotting of information. Second is an optimization routine designed to aid in the selection of the optimum EA-6B route of flight, when in a Modified Escort role.

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EA-6B Mission Planning and Route Optimization Program

by

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Lieutenant, United States Navy
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The EA-6B Mission Planning and Route Optimization Program was created for use with the WANG 2200 computer system by aircrewmen deployed on board aircraft carriers. It is an interactive computer program designed to increase the effectiveness and efficiency of the mission planning process, while reducing the time involved in this evolution. These goals are accomplished through the use of two schemes. First is an automation of the clerical planning tasks of retrieval, listing, and plotting of information. Second is an optimization routine designed to aid in the selection of the optimum EA-6B route of flight, when in a Modified Escort role.

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I. INTRODUCTION

Many exercises or problems that have previously been tediously solved by man directly may now be dealt with by small, readily available, economically efficient computing devices. Airborne electronic warfare mission planning is this type of exercise. In recent years this already time-consuming and exacting process has become increasingly complex due to the high degree of sophistication of electronic warfare weapons systems and the threats they must deal with. Powerful state of the art airborne computers are used with these weapons systems to aid the Electronic Warfare Officer in performing his mission. However, until this time, no automated interface has been utilized to correlate the vast amounts of data that must be considered in the mission planning process if effective weapons system utilization is to be achieved.

Electronic warfare mission planning lends itself readily to solution by interactive computer programming. Initial stages of mission planning involve the collection of information from a variety of sources, including TACMANUALS, Electronic Orders of Battle (EOB), Kilting lists, radar handbooks, etc. From this information, charts are marked showing EOB, route of flight, and emitter detection envelopes. Detailed data lists and time logs must also be made before the operator can effectively determine, through the use of cumbersome jamming effectiveness equations of dubious applicability and

personal expertise, the optimum course of action for the mission. This procedure routinely can take many hours to effectively reach a solution. However, due to the nature of strike planning, the luxury of these extended time periods is not always available and corners have to be cut. The inefficiency in this process is obvious, and can, under certain circumstances, be unaffordable.

Any or all of these steps in the electronic warfare mission planning process can be greatly simplified through the use of a combination of current computer hardware and interactive software. Depending on the degree of automation, it is conceivable that mission planning time could be reduced by a factor of ten with more accurate results than possible by hand.

II. BACKGROUND

Initial research into the automation by computer of the electronic warfare mission planning process was completed in June 1977 [1, 2]. Each of the papers resulting from this research dealt with a particular section or facet of the mission planning process.

In Beaudet [1], computer software was developed which automates many of the initial processes of electronic warfare mission planning. In his development, Beaudet has utilized a series of operator-computer interfaces which, while greatly helping to eliminate a substantial portion of the mission planning drudgery, still keeps the planner integrally involved in and aware of every step of the planning process. This technique of interactive programming is completely essential in any mission planning program.

Specifically, the "EA-6B Mission Planning Program" [1] is designed to accomplish the following:

1) Based on entered latitudes and longitudes, plot a strike route of flight,
2) Produce a complete printout of the area EOB based on information from step 1,
3) Visually present various emitter detection envelopes and the route of flight based on steps 1 and 2,
4) Compute and print out hard copies of the complete navigation solution and threat emitter reaction information, including minute-by-minute range and bearing to emitters within detection range.

This simulation was accomplished utilizing the following hardware:

1) IBM 360/67 general purpose computer,
2) TEKTRONIX 4012 graphics terminal (30/12 system),
3) TEKTRONIX 4610 hard copy printing unit.

FORTRAN computer language was used in this program, which consisted of approximately 800 steps and 10k of computer memory.

It is important to notice that this simulation does not completely address the mission planning problem. That is, while much of the initial collating, sorting, and plotting work has been automated, the operator still must make the crucial decisions to determine the flight route providing the most effective jamming. While it is true that in many cases the optimum EA-6B route will be obvious from information presented by this program, when the solution is not obvious large amounts of time and effort, not always available, are required to make the proper decisions.

In Ref. [2], Watts deals with the problem of determining an optimum route for a jamming aircraft. In this paper, he presupposes a Modified Escort route for the jamming aircraft and bases his simulation on this supposition. In this type of mission, the electronic warfare aircraft accompanies the strike group only in areas of low exposure to enemy threats. This type of route, in general, increases the survivability of the Electronic Countermeasures (ECM) aircraft, but decreases the jamming effectiveness when compared with a direct accompaniment role.

Watts' simulation determines an optimum route by calculating the point where the strike group exposure to threats is greatest. For this position and time, an optimum position for the jammer platform is computed within certain constraints. Next, it computes a route to and from this point, which in theory approaches the absolute optimum route. In actuality, the simulation calculates several optimum routes, each with its own measure of effectiveness (MOE), and presents them to the operator allowing him to make a choice based on his own expertise and the MOE's.

It is obvious that these two theses, which have provided some of the background for this research, have attacked the problem of airborne electronic warfare mission planning from two diverse approaches. Reference [1] has sought to automate much of the plotting, listing, and collating of information necessary in the mission planning process. Reference [2] has tried to eliminate the difficult and time consuming processes required in determining an optimum ECM route to fly when protecting a strike group.

It would appear that the logical solution to the mission planning quagmire lies somewhere in a compromise between or combination of the two approaches. This is the premise from which this research was begun.

III. DESIGN CONSIDERATIONS

The primary objective in the creation of this program was to create an effective automation of the mission planning process, utilizing existing assets on board U.S. aircraft carriers. Accuracy, speed, simplicity, cost effectiveness, and direct user interface were the primary design goals. The limitations of existing hardware assets played a significant role in many facets of the design. The final mission planning system developed exhibits the influence of these factors.

In the development of the program, it was paramount that, to as great an extent as possible, existing equipment on board U.S. carriers be used. Most computer systems on board the carriers are either inaccessible to EA-6B squadron aircrews or presently so overworked that usage would be impractical. However, all carriers are now or soon will be equipped with a WANG 2200 computer system. Included in this on board system are the following:

1) Central processing unit (CPU) of 16k capacity,
2) Video display unit,
3) Flexible disk auxiliary storage unit utilizing 250k disks,
4) High speed hard copy printing unit.

This equipment is located where easy access and use by EA-6B aircrew personnel is possible. All software in this mission planning and route optimization program has been designed for use on this system.

In its design, the goals of this program were divided into two distinct areas:

1) Automation of the clerical functions of planning (i.e., sorting, plotting, listing, etc.)
2) Optimization of the jamming problem.

Initially, the first objective was to have been accomplished by simply converting Beaudet's "EA-6B Mission Planning Program" [1] to BASIC computer language, for use with the WANG system. However, due to the increased size of this program when converted to BASIC, and the limited core size of the WANG machine, it was necessary to completely restructure this program for efficient use with the WANG system.

The resulting program is one which utilizes the WANG flexible disk system to "page" itself in and out of the computer's core memory. Specifically, what was done was to divide the program into several logical sections. The first of these sections consisted of information that must remain within the central processing unit (CPU) at all times, such as variable definitions and constants used throughout the program. Initially, only this first section of programming is loaded from the disk into computer memory. As the program progresses, the various other sections are moved in and out of core memory, one at a time, as they are called for.

This process of overlaying parts of the program on top of a section of permanent core resident code effectively increases the apparent size of the WANG CPU memory from 16k to whatever size is necessary. The penalty for this is obviously an

increase in the running time of the program caused by the additional time required to bring information in from the flexible disk system more than once. However, this fully automatic process, due to the nature of the disk system, is a very rapid one. The increase in running time is minimal.

The sequence of events and overall results of this section of programming closely resemble those of [1]. To this section of this program, however, was added an optimization of the jamming problem for the Modified Escort mission profile.

Computer optimization of the jamming problem consists of finding the optimum route to fly to maximize jamming protection for a strike group. The three types of strike support missions that EA-6B aircraft generally fly are Standoff, Escort, and Modified Escort. Of these, the Modified Escort mission profile is best suited for a route optimization.

In view of the core size problems already encountered with the automation of clerical tasks, it was obvious that the type of optimization done in the "Electronic Warfare Support Jamming Pre-Mission Route Optimization" [2] was not possible. Not only is the program quite large (10k in FORTRAN), but, because of the large number of calculations it performs, run time on the WANG system would be excessive. However, [2] provided ideas for a simplified optimization routine.

The one overriding design consideration for the development of the optimization was simplicity. The reasons for this are two-fold. First is the obvious problem of a small core-sized computer with an already large mission planning program.

The second reason is not so obvious and concerns itself with the parameters for optimization.

Any optimization is based on some measure of effectiveness (MOE) as the governing parameter. The MOE for jamming has, for many years, been the jamming to signal (J/S) equation. However, with the advent of the highly sophisticated jamming modes of the EA-6B, the J/S ratio has been shown to be not a totally valid MOE. With this in mind, an optimization based on a rigorous application of the J/S ratio was deemed to be inappropriate.

What was developed was a simple optimization based on the presence of jamming aircraft in the threat radar beam width, distance from the threat radar, strike group position, and EA-6B possible positions. It is not stipulated that this scheme produces the definitive optimum route for all situations involving all types of jamming. Instead, what is accomplished is the presentation of a computer designed route that approaches the optimum and indicates to the operator another possible solution to his problem.

In view of the storage limitations of the WANG system, the mission planning and route optimization program requires that certain information be retrieved from one of the ship's main computers. The task of developing an interface between the ship's computer and the WANG system has been assigned to the Navy Ocean Systems Center (NOSC) in San Diego. This interface, currently under development, is essential to this program.

Contained in the ship's main computer is current EOB information. This information, pinpointing the location of various emitters, is sorted with the EA-6B Parameter Library file, contained on the WANG flexible disk. The result of this sort is the EOB listing, containing the following information:

1) Site number,
2) Latitude and longitude of each emitter,
3) Threat type, e.g., Spoon Rest or Barlock,
4) Frequency band and frequency range of emitter,
5) Emitter function, e.g., Early Warning or Missile Control,
6) PRF range,
7) Automatic and manual jamming codes for use against the emitter,
8) Percent of frequency band of the emitter.

The retrieval of information from the ship's computer is designed to be a fast and simple one. Very little ship's computer CPU time is used in this exchange.

IV. SYSTEM DESCRIPTION

EA-6B Mission Planning and Route Optimization Program uses the WANG 2200 computer system interfaced with the TEKTRONIX 4012 graphics terminal. It was written in WANG BASIC computer language and, along with associated data, was stored on a 250k capacity flexible disk.

The program is divided into four distinct sections, based on mission profile. The missions available are Escort, Modified Escort, Standoff, and Modified Escort with route optimization. The operator initiates the planning process by selecting one of the four profiles for consideration. Selection of the profile with route optimization results in slightly different user options and procedures from the other three mission. The three similar missions will be discussed first.

Following selection of the mission, the operator enters either the strike group route of flight, if known, or simply the target latitude and longitude. At this point, using the interface with the ship's main computer, a printout of the local area EOB is presented to the planner. Subsequently, the strike route of flight, location of emitters, and detection ranges of emitters are displayed on the graphics unit. With this visual display, the optimum jamming route of flight may be apparent to the planner, or it may be obscured by a complex strike route and dense emitter environment. In the latter case, the operator at this time may select the route

optimization section of the program for computer assistance in selecting the jamming route.

Assuming the planner continues with his originally selected mission, he may now enter his EA-6B route of flight or change his strike route to view a different EOB. If he is unsure about the best strike route, he may wish to have the computer plot several different strike routes with associated EOB's on a transparent overlay. This overlay may then be attached to the appropriate chart for presentation to the strike leader for his consideration.

Once the planner has narrowed his options down to his final strike and EA-6B routes, he may obtain a mission chart from the WANG drum plotter containing the following information:

1) Strike group route,
2) EA-6B route,
3) Location of EOB emitters,
4) Emitter detection envelopes.

He may also obtain from the printer a complete navigation solution and Time Scenario for use during his mission. The Time Scenario contains information required by the EA-6B Electronic Countermeasures Officer to effectively conduct the mission. Included are a minute-by-minute listing of emitters within detection range of the strike group and various Tactical Jamming System (TJS) related information for countering these threats.

With any of the first three missions, the operator has the option of selecting and visually considering as many combinations

of routes and missions as he desires. However, he alone must make all significant planning decisions, resulting in the final strike route and/or EA-6B route. The success of his choices is based completely on his expertise and insight, without computer assistance in finding the optimum route.

If the Modified Escort mission with route optimization is chosen, a strike route of flight must be entered before the optimization routine is started. In this mission, the EA-6B accompanies the strike group until it enters a terminal threat weapon's envelope. At this point, jamming effectiveness calculations begin and determine the direction of flight for the EA-6B.

With the EA-6B position fixed on the terminal threat weapon's envelope, a minute-by-minute direction of flight is determined based on two factors:

1) The angle formed by the EA-6B, strike group, and the radar, the optimum angle being zero degrees or a straight line from the radar to the strike group to the EA-6B.

2) A radar weighting factor assigned on the basis of radar type, associated weapons system, and vulnerability to EA-6B jamming.

These two parameters are computed and summed for radars within detection range to determine a measure of effectiveness (MOE) given by:

$$\text{MOE} = \sum_{i=1}^{n} r_i \Theta_i^2$$

Where: r_i = radar weighting factor

Θ_i = offset angle

n = total number of radars considered

Each $r_i \Theta_i^2$ term has a maximum default value determined by the radar beam width and maximum angle offset for effective EA-6B jamming. Once a term reaches its maximum value, it is eliminated from the summation.

The MOE summations are made for several possible EA-6B positions, which are constrained by the flight path and aircraft airspeed. The position with the minimum summation value is chosen for the optimum jamming position. This process is then repeated for the next minute with a new strike group position and new EA-6B positions. The final result is the optimum route based on MOE calculations and route constraints.

The operator at this point is presented with a visual display of the optimized EA-6B route, strike group route, emitter locations, and emitter detection envelopes. He may elect, based on this presentation, to alter his strike route, default to another mission section of the program, or continue with the computed route. If he continues, as in the other program sections, he will obtain the complete EA-6B and strike group navigation solutions, Time Scenario, and plotted chart for the mission.

From this description, it is evident that regardless of which mission is chosen, the mission planner is still the key element in the process. His imagination, training, and experience must be interactively used with this computer program if an effective solution to the mission planning problem is to be achieved.

V. USER'S GUIDE TO THE PROGRAM

A. INTRODUCTION

The following section contains a detailed explanation of how to use this mission planning system and the equipment associated with it. It is envisioned that the User's Guide will accompany the program to the Fleet, facilitating its implementation.

B. STARTING THE PROGRAM

Using the EA-6B Mission Planning and Route Optimization Program is not a difficult task. By simply following a few simple procedures and answering a few questions, many hours of tedious planning can be eliminated. Detailed information on procedures for using the WANG computer system can be found in [3 and 4].

The initial step in using this system is to load the program and the flexible disk containing the program, as in [4]. To load section one of the program from the disk into the core memory, the operator must type the command, LOAD DC F "MAIN1," and then push the RETURN(EXEC) button. This is the only load command necessary in the entire program. All other sections of the program are automatically loaded from the disk as they are required.

The program is started by pushing the RETURN(EXEC) button one more time. The program will then ask a series of questions

from which it determines how to assist the operator in the mission planning process. All questions are answered by merely typing in the appropriate number for the desired response and pushing the RETURN(EXEC) button.

Under normal circumstances, the planner will have a particular mission and strike route to consider when he starts planning. For ease in the explanation of the program flow, it will be assumed that this is the case. It is, however, possible to select these items after viewing the local EOB based on the mission's starting point and target.

C. ESCORT MISSION

The Escort mission profile is one in which the EA-6B accompanies the strike group for the entire route of flight. This mission will be discussed first.

After the selection of the mission, the operator is asked to enter the strike group route of flight, including number of turnpoints, latitude and longitude of each turnpoint, airspeed on each leg, and local magnetic variation. The system then calculates a geographic window around this route which is passed to the ship's main computer. Based on this window, the ship's computer returns positions and types of local threat emitters. This information is then sorted with the Emitter Parameter Library contained on the flexible disk. The result is the EOB listing pertinent to the mission. At this time the operator has the option to add additional information or sites to this EOB, or ignore it completely and build his own EOB.

Once the EOB listing is completed, the planner has the option of obtaining a hard copy of the complete listing or of only a portion of the listing based on class of emitter, i.e., EW/ACQ or Terminal Threat radars. The listing contains various radar parameters that are of particular significance to EA-6B personnel, as seen in Fig. 1.

The operator is now asked several questions related to the visual display of the EOB and route information. Through these questions he has the option of filtering the classes of emitters to be plotted on his display or chart. Once this decision has been made, the route of flight, emitter locations, and emitter detection envelopes are plotted, as seen in Figs. 2, 3, 4. At this point, the operator may elect to have the plotter transfer this information onto a navigation chart for use during the mission. This process will normally take several minutes.

The planner is now given the opportunity to obtain a navigation solution and a Time Scenario. The navigation solution (Fig. 8) contains the following information:

1) Distance of each leg,
2) Time to fly each leg,
3) True and magnetic headings to each turnpoint,
4) True airspeed for each leg,
5) Total time,
6) Total distance,
7) Latitude and longitude of turnpoints.

The operator is given the opportunity to obtain a hard copy of this listing from the printer. If he does not want a navigation solution, he may consider a different route or mission at this time.

The Time Scenario, as discussed in the System Description, is a minute-by-minute listing of pertinent EA-6B jamming information. The operator is now asked if he wants a listing of this Time Scenario. If he does, the system calculates and prints the following information for each minute of the mission (see Fig. 9):

1) Time,
2) Present position,
3) Emitters within detection range,
4) Correlation number to the EOB listing,
5) Range and bearing to the emitter,
6) Automatic and degraded systems jamming modes to use,
7) Relative percent of Onboard System frequency band of the emitter.

The information listed here must be at the disposal of EA-6B aircrew personnel during a mission for immediate reaction to threat radars. Previously, this information was painstakingly extracted from a variety of sources before each mission. Only with this detailed information available during a mission can the EA-6B systems operator hope to cope with the unexpected events and confusion which takes place during a strike mission.

At this point in the planning process, the operator is asked if he wants to consider another mission or strike route.

If he is satisfied with the solution he has obtained, he simply answers "no" to these questions and the program stops.

D. STANDOFF MISSION

A Standoff jamming mission is normally one in which the EA-6B stays in a particular fixed orbit while the strike group ingresses to a target. During this time, the EA-6B concentrates its jamming primarily on EW/ACQ radars to mask the route and composition of the strike group. EA-6B jamming effectiveness against narrow beam missile control radars is less than completely effective when not in alignment with the strike group and emitter. During this time, the EA-6B will normally proceed to another optimum jamming point and fly a fixed orbit. From this orbit, jamming will be provided to effectively cover EW/ACQ radars during the egress portion of the strike route.

This program allows the operator a chance to rapidly view the effects of his jamming from several different standoff points during the planning session. In viewing different standoff points, he should be able to chose the position or positions which will provide the desired jamming protection for ingress and egress of the strike group.

Once the mission has been selected and strike route entered, the program asks for the latitude and longitude of the standoff point. It will normally suffice to enter the midpoint of the first standoff orbit. The system will now display the strike route, EOB emitter sites and detection

envelopes, and the EA-6B standoff point. As with the Escort mission, the operator has the ability to filter the emitters displayed by class. With the Standoff mission only, the planner may also elect to see the emitter detection envelopes depressed by his jamming as in Figs. 5 and 6. This feature enables him to rapidly assess the effectiveness of jamming from several different locations, leading to the selection of one or more standoff points for the mission.

Once the planner is satisfied with the display he has constructed, as before, he may transfer the display information to a chart via the plotter. The navigation solution and jamming parameters for use in flight, as seen in Fig. 11, may now be printed, concluding the planning of this particular mission.

The success of the Standoff mission lies primarily in the selection of the optimum standoff points. With the aid of this system, the planner is able to rapidly view many different standoff points, resulting in near optimum positioning of the EA-6B.

E. MODIFIED ESCORT MISSION

A Modified Escort mission is one in which the EA-6B accompanies the strike group until the point where the strike group must penetrate a AAA or SAM envelope. At this point, the EA-6B takes up a course outside of the weapons envelopes. In an environment of sophisticated home-on-jam (HOJ) missiles, a modified escort role seems a likely possibility for jamming aircraft.

Once the mission has been selected and the strike route entered, as before, the operator may enter the EA-6B route. However, it is envisioned that normally the planner will first view the EOB listing and the display of EOB emitter locations, emitter detection envelopes, and strike route. Based on this information, he can now intelligently chose and enter the EA-6B route.

When this is accomplished, the EA-6B route is added to the visual display as in Fig. 7. As before, the operator may have his chart marked with this information or consider another strike route or routes. A navigation solution and Time Scenario are again available at this point. Figure 8 shows the navigation solution containing both strike group and EA-6B information. The Time Scenario for the Modified Escort mission is seen in Fig. 10. It considers both strike group and EA-6B position, and lists emitters accordingly. As with all other missions, at this point in the program the operator may select a new mission profile, change the route, or merely terminate the planning session.

F. MODIFIED ESCORT MISSION WITH ROUTE OPTIMIZATION

Results obtained in this section of the program are likely to be very similar to those of the Modified Escort section. In this section, however, the computer makes some important decisions for the planner.

Once the mission is selected, the strike route of flight, including turnpoints, speeds on each leg of the route, and local magnetic variation, must be entered. As in all other

sections, the EOB listing is now created utilizing the interface with the ship's main computer, the Emitter Parameter Library, and operator inputs. This listing is available to the operator for viewing and printout at this point in the program.

The planner is next asked to enter the minimum and maximum EA-6B airspeeds he wishes the computer to use in the optimization routine. With the input of this information, the program automatically enters the routine and computes an optimized EA-6B route based on the calculations and constraints outlined in the System Description section.

When the route is completed, the system plots the optimized EA-6B route, strike route, terminal threat radar positions and detection ranges on the graphics terminal. The operator has the option of adding EW/ACQ radars to the display before he has the display plotted on his chart. At this point in the program, the planner may change the strike route and reinitiate the optimization routine, change his mission, or continue with what he has done.

Assuming the planner was satisfied with the display, following the preparation of the chart, he may list and print a navigation solution and Time Scenario identical to those of the Modified Escort mission (Figs. 8 and 10). At this point, the operator is again given the opportunity to change his route, mission, or terminate the planning session.

In the dense emitter environment of many areas of the world, computer assistance in the selection of an optimum jamming route is essential. Use of the Modified Escort mission program section in such an environment would be extremely time consuming, requiring the planner to view many different EA-6B routes before being able to intelligently decide on a route. With the route optimization section implemented, under such conditions planning time would be reduced and far more accurate results would be achieved.

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  2  TALL KING    EW      2  100. 5    100  200  100  200  200  240  FT7  WFT  46   NONE
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  4  SPOON RST NC EW      2  150. 3    100  130  120  180            FT2  WFT  46   SA-2 ACQUISITION
      27.27    -99.29
  5  LOW BLOW     MC      0   10. 17   8725 8775 1.20 +-50           T900 WSS  83   SA-3, LOW ALT 150FT, E-O BACKUP
      27.30    -97.33
  6  SPOONST B    EW      1  120. 6    50   60   60   50             FT4  WFT  28   NONE
      27.30    -97.37
  7  FIRE WHEEL   FC      7    5. 11   2690 2720 1800 1900           T485 SS1  19   AAA, CONSCAN
      27.34    -97.21
  8  FANSONG C-E  MC      3   20. 15   4200 4250 800  850  1600 1700 T902 WSS  36   SA-2,CCI PCM AT 800MHZ,E-O BACKUP
      27.34    -97.12
  9  STRAIT FLUSH MC      3   10. 15   4210 4250 3080 4000           T385 WSS  12   SA-6, ACQ-TRKR, FAST FLYER, 3-6 SEC
      27.35    -97.22
 10  BARL-STRAP G EW      7   90. 11   2050 2080 420  430  540  560  FT3  WFT  21   FREQ, 6 BEAMS, SIMPLE PRF 330
      28.31    -98.06
 11  TALL KING    EW      2  100. 3    100  200  100  200  200  240  FT7  WFT  46   NONE
      28.41    -96.43
 12  FIRECAN      FC      7    5. 11   2710 2750 2500 2520           T377 SS3  32   AAA, CONSCAN
      28.44    -97.03
 13  STRAIT FLUSH MC      3   10. 15   4210 4230 3080 4000           T385 WSS  12   SA-6, ACQ-TRKR, FAST FLYER, 3-6 SEC
      29.10    -98.01
 14  LOW BLOW     MC      0   10. 17   8725 8775 1.20 +-50           T900 WSS  83   SA-3, LOW ALT 150FT, E-O BACKUP
      29.20    -98.10
 15  WHIFF        FC      7    5. 11   2620 2640 2000 2050           FT3  SS2  27   AAA, CONSCAN
      29.23    -98.23
 16  LOW BLOW     MC      0   10. 17   8725 8775 1.20 +-50           T900 WSS  83   SA-3, LOW ALT 150FT, E-O BACKUP
      29.38    -98.38
 17  LOW BLOW     MC      0   10. 17   8725 8775 1.20 +-50           T900 WSS  83   SA-3, LOW ALT 150FT, E-O BACKUP
      29.15    -98.38
```

Figure - 1 Listing of E.O.B. with EA-6B pertinent parameters.

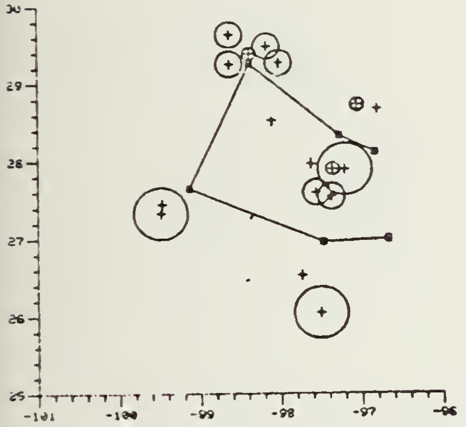


Figure - 2 Visual presentation for an escort mission profile with only terminal threat (fire control, missile control) emitter detection envelopes displayed. Site locations +, and route of flight —■— are shown. The scale indicates lat/long with the convention N/S = +/-, and E/W = +/-.

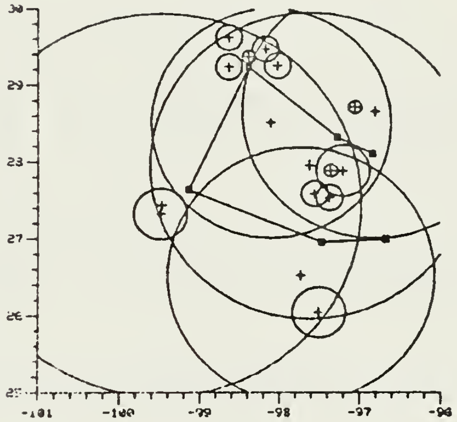


Figure - 3 Visual presentation for an escort mission profile with all emitters and their detection envelopes presented. Site locations +, and route of flight —■— are shown, and the scale indicates lat/long with the convention N/S = +/-, and E/W = +/-.

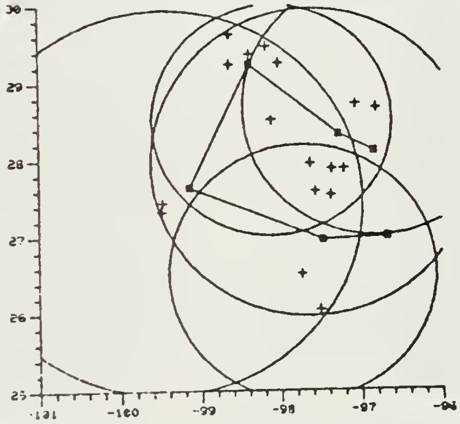


Figure - 4 Visual presentation for an escort mission profile with only early warning/acquisition type radar detection envelopes presented. Site locations +, and route of flight —■— are shown. Scale indicates lat/long with the convention N/S = +/-, and E/W = +/-.

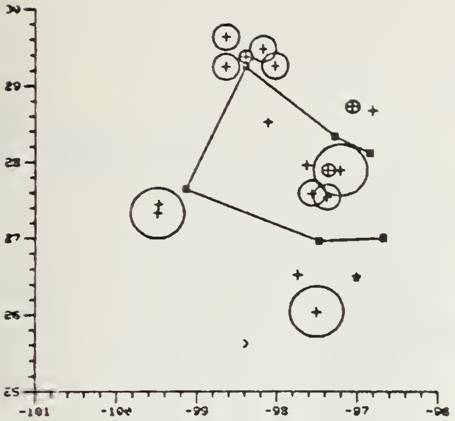


FIGURE - 5   SHOWS STRIKE GROUP ROUTE, STANDOFF JAMMER POSITION •, AND TERMINAL THREAT EMITTER ENVELOPES (NOT DEPRESSED BY JAMMING).

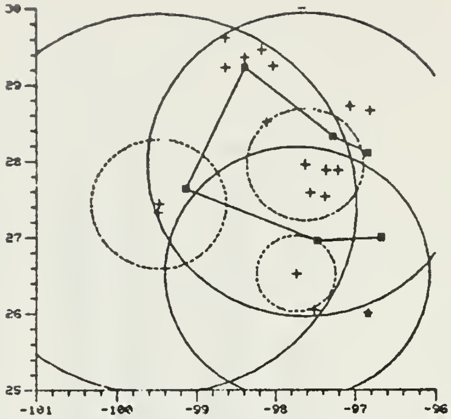


FIGURE - 6   SHOWS STRIKE GROUP ROUTE, STANDOFF JAMMER POSITION •, EW/ACQ EMITTER ENVELOPES UNJAMMED (SOLID LINES) AND JAMMED (DASHED LINES).

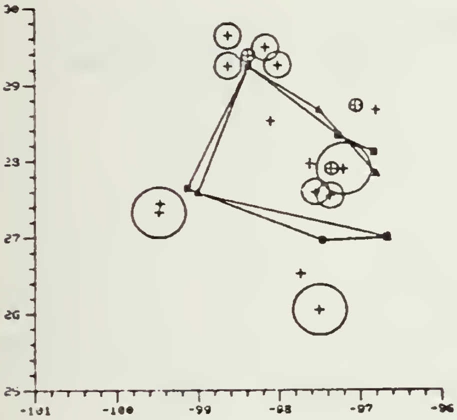
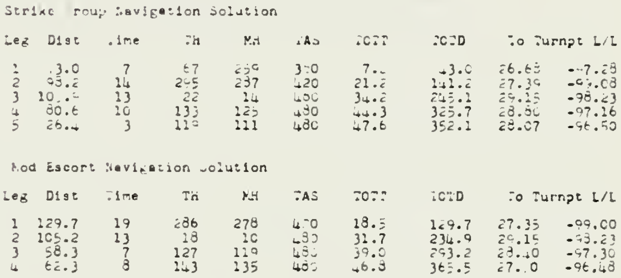


FIGURE - 7   SHOWS STRIKE GROUP ROUTE ■, EA-6B ROUTE ▲, AND TERMINAL THREAT EMITTER ENVELOPES (NOT JAMMED).



```
Strike Group Navigation Solution

Leg  Dist   Time    TH    MH   TAS    TOTT     TOTD    To Turnpt L/L

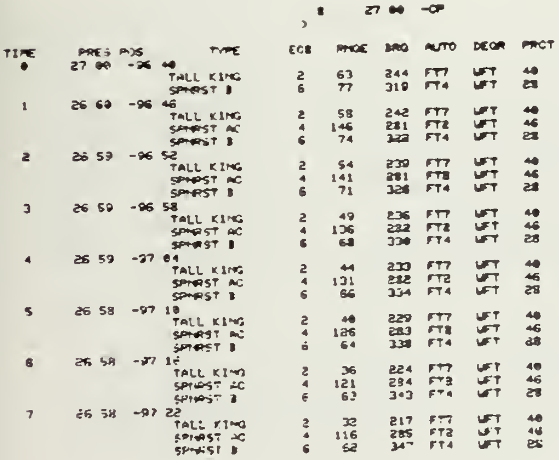
 1   43.0     7     67    59   360    7.[illegible]     43.0   26.65  -97.28
 2   93.2    14    245   237   420    21.2    141.2   27.39  -99.08
 3   10[illegible]    13     22    14   450    34.2    245.1   29.15  -98.23
 4   80.6    10    133   125   480    44.3    325.7   28.80  -97.16
 5   26.4     3    119   111   480    47.6    352.1   28.07  -96.50

Mod Escort Navigation Solution

Leg  Dist   Time    TH    MH   TAS    TOTT     TOTD    To Turnpt L/L

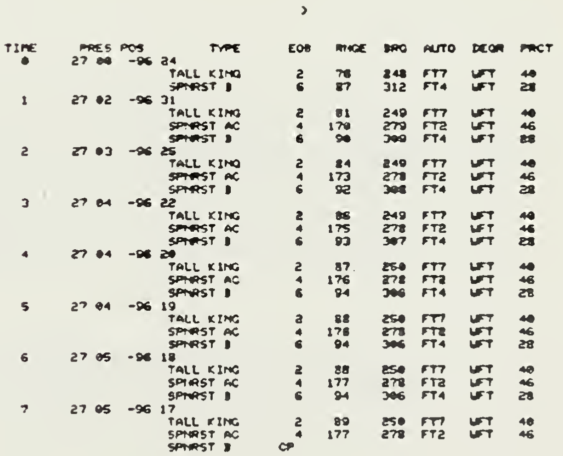
 1  129.7    19    286   278   420    18.5    129.7   27.35  -99.00
 2  105.2    13     18    10   480    31.7    234.9   29.15  -98.23
 3   58.3     7    127   119   480    39.0    293.2   28.40  -97.30
 4   62.3     8    143   135   480    46.8    365.5   27.00  -96.48
```

FIGURE - 8   THIS IS A LISTING OF THE STRIKE GROUP AND EA-6B NAVAL SOLUTIONS FOR A MODIFIED ESCORT MISSION.



```
                                     8      27 00   -CP
                                   >
TIME     PRES POS       TYPE       EOB   RNGE  BRG  AUTO  DEGR  PRCT
 0     27 00   -96 40
                     TALL KING      2     63   244  FT7   UFT    40
                     SPNRST B       6     77   310  FT4   UFT    28
 1     26 60   -96 46
                     TALL KING      2     58   242  FT7   UFT    40
                     SPNRST AC      4    146   281  FT2   UFT    46
                     SPNRST B       6     74   322  FT4   UFT    28
 2     26 59   -96 52
                     TALL KING      2     54   239  FT7   UFT    40
                     SPNRST AC      4    141   281  FT2   UFT    46
                     SPNRST B       6     71   328  FT4   UFT    28
 3     26 59   -96 58
                     TALL KING      2     49   236  FT7   UFT    40
                     SPNRST AC      4    136   282  FT2   UFT    46
                     SPNRST B       6     68   330  FT4   UFT    28
 4     26 59   -97 04
                     TALL KING      2     44   233  FT7   UFT    40
                     SPNRST AC      4    131   282  FT2   UFT    46
                     SPNRST B       6     66   334  FT4   UFT    28
 5     26 58   -97 10
                     TALL KING      2     40   229  FT7   UFT    40
                     SPNRST AC      4    126   283  FT2   UFT    46
                     SPNRST B       6     64   338  FT4   UFT    28
 6     26 58   -97 16
                     TALL KING      2     36   224  FT7   UFT    40
                     SPNRST AC      4    121   284  FT2   UFT    46
                     SPNRST B       6     63   343  FT4   UFT    28
 7     26 58   -97 22
                     TALL KING      2     32   217  FT7   UFT    40
                     SPNRST AC      4    116   285  FT2   UFT    46
                     SPNRST B       6     62   347  FT4   UFT    28
```

FIGURE - 9   THIS IS A PORTION OF THE TIME SCENARIO FOR AN ESCORT MISSION SHOWING PARAMETERS NECESSARY TO ANTICIPATE ALL KNOWN SITES, AND TO REACT TO SYSTEM MALFUNCTIONS CAUSING DEGRADED MODE OPERATION WITH A MINIMUM OF CALCULATION. ALL SITES ARE ONLY LISTED IF THE STRIKE GROUP IS WITHIN THE DESIGNATED DETECTION RANGE.



```
                                   >
TIME     PRES POS       TYPE       EOB   RNGE  BRG  AUTO  DEGR  PRCT
 0     27 00   -96 34
                     TALL KING      2     78   248  FT7   UFT    40
                     SPNRST B       6     87   312  FT4   UFT    28
 1     27 02   -96 31
                     TALL KING      2     81   249  FT7   UFT    40
                     SPNRST AC      4    170   279  FT2   UFT    46
                     SPNRST B       6     90   309  FT4   UFT    28
 2     27 03   -96 25
                     TALL KING      2     84   249  FT7   UFT    40
                     SPNRST AC      4    173   278  FT2   UFT    46
                     SPNRST B       6     92   308  FT4   UFT    28
 3     27 04   -96 22
                     TALL KING      2     86   249  FT7   UFT    40
                     SPNRST AC      4    175   278  FT2   UFT    46
                     SPNRST B       6     93   307  FT4   UFT    28
 4     27 04   -96 20
                     TALL KING      2     87   250  FT7   UFT    40
                     SPNRST AC      4    176   278  FT2   UFT    46
                     SPNRST B       6     94   306  FT4   UFT    28
 5     27 04   -96 19
                     TALL KING      2     88   250  FT7   UFT    40
                     SPNRST AC      4    178   278  FT2   UFT    46
                     SPNRST B       6     94   306  FT4   UFT    28
 6     27 05   -96 18
                     TALL KING      2     88   250  FT7   UFT    40
                     SPNRST AC      4    177   278  FT2   UFT    46
                     SPNRST B       6     94   306  FT4   UFT    28
 7     27 05   -96 17
                     TALL KING      2     89   250  FT7   UFT    40
                     SPNRST AC      4    177   278  FT2   UFT    46
                     SPNRST B     CP
```

FIGURE - 10   THIS IS A PORTION OF THE TIME SCENARIO PRINTOUT OF A MODIFIED ESCORT MISSION. ANGLES ARE FROM THE EA-6B TO VARIOUS EMITTERS. EMITTERS ARE LISTED IF EITHER THE STRIKE GROUP OR THE EA-6B ARE WITHIN THE DESIGNATED ENGAGEMENT RANGE.

```
STANDOFF L/L            TYPE         EOB    RNGE   BRG  AUTO  DEGR  PRCT
  26.00  -96 50
                   FANSONG B-F      1     36.   375  T550  WSS    44
                   TALL KING        2     58    304  FT7   WFT    40
                   SPNRST AC        4    165.   308  FT8   WFT    48
                   LOW BLOW         5    103    338  T900  WSS    83
                   SPNRST B         6    125.   340  FT4   WFT    23
                   FIREWHEEL        7    117.   348  T483  SS1    18
                   BRLK-BGBAR B    10    165.   336  FT3   WFT    21
                   TALL KING       11    161.     1  FT7   WFT    40
                   FIRECAN         12    164    356  T377  SS3    32
                   LOW BLOW        14    221    341  T560  WSS    83
                   WHIFF           15    219    332  FT3   SS2    27
                   LOW BLOW        16    238.   336  T900  WSS    83
                   LOW BLOW        17    222.   332  T960  WSS    83
```

FIGURE - 11 JAMMING PARAMETERS FOR A STANDOFF MISSION FROM ORBIT POINT INDICATED.

```
                              KASHIN    DLG

ARMAMENT:   SAM    20 x SA-N-15  (2 TWIN)

            GUNS   4 x 50MM (TWIN MOUNT)

            ASW    2 x RBU- 1000
                   2 x RBU- 2000
                   4 x 10 IN. TORPEDOES

            A/C    1 x HORMONE

ELECTRONICS:

EMITTER  FUNC BAND LIST RNGE  FLO  FHI  PRF1 PRF1 PRF2 PRF2 AUTO DEGR PRCT REMARKS
BIG BOY   EW    1    4   100   25   50   100  110 ---- ---- S123  WSS  12  PRIMARY AIR SCH
BAD NEWS  EW    4    2    50  100  200   250  269 ---- ---- FT20  WFT  23  NONE
POPCORN   FC    7   15    22 2000 2100  1000 1010 ---- ---- T321  WSS  44  AAA, E-O ALSO

DON-2    NAV    9   12     8 4000 4400  8800 8900 9300 9400 FTC3 NFT2 67  NONE
FOOLYA    MC    8   30    45 6000 7000  1800 1850 ---- ---- T456  NSS  97  SA-N-15, DLJ
```

FIGURE - 12 TYPICAL PRINTOUT OF EA-6B PERTINENT INFORMATION BY WEAPON PLATFORM.

VI. FUTURE CONSIDERATIONS

A. INTRODUCTION

Due to equipment restrictions, many features that would be nice to have in a mission planning program are not included in this system. Without great modifications to the existing program, all items discussed in this section could be incorporated, expanding the features and versatility of this system.

B. HARDWARE

If the WANG 2200 computer system is to continue to be the basis for EA-6B mission planning, procurement and utilization of the newly developed WANG Interactive Graphics Terminal is advisable. Not only are interface problems, now present with the TEKTRONIX 4012, avoided with this display system, but the speed in creating necessary displays is substantially increased.

The WANG computers used onboard carriers and the one used for development of this program have 16k of CPU memory. With only slight hardware modification and minimal cost, this memory can be increased to 64k. If this mission planning program is to be expanded and improved, it is vital to have the increased core size available.

Should a dedicated computer system become available for EA-6B mission planning, consideration should be given to all manufacturers of computing systems with similar capabilities to the WANG 2200. Included in this category are the HEWLETT PACKARD 9845 and the TEKTRONIX 4051 computer systems.

Each system has specific advantages which must be fully investigated before any choice is made.

C. SOFTWARE

The Emitter Parameter Library and ship's computer interface could be modified to produce an EOB listing with information on specific weapon platforms. Information on ships and aircraft of interest could be displayed and printed, as in Fig. 12. This procedure would not involve a significant increase in computer calculations.

Expansion of the optimization aspect of this program seems inevitable. In spite of the limited CPU memory size of the WANG machine, a simple optimization of the Standoff mission is possible. In this routine, jamming effectiveness calculations could be used to determine optimum standoff positions for strike group protection. Many sections of programming currently in the system could be used in this scheme.

Programming to determine the strike route with the minimum amount of exposure to enemy radars could easily be added to the existing system. A procedure which examines several possible strike routes and calculates exposure times and trends could be used to implement this feature into the program. Combining this routine with jamming route optimization could lead to a complete automation of the mission planning process.

APPENDIX A

EA-6B MISSION PLANNING AND ROUTE OPTIMIZATION PROGRAM

PROGRAMMED IN WANG 2200 BASIC LANGUAGE

PART ONE "MAIN1"

```
10 REM MAIN PROGRAM FOR EA6B MISSION PLANNING
20 DIM X1(10),Y1(10),S1(20),S2(20),S6(20),D1(9),S3(9),T3(9),
   N2(9),M3(9),Z1(9),T4(120),S4(20),T2(9),D4(9),N1(8),T8$(30
   )12,T1(30)
30 DIM T7$(30)36,Y2(9),X2(9),M2(9),S5(9),P2(9),B(30),G1(30),
   P1(30),G2(30),T6(9),T5(9),D2(9),D3(9),N3(9),M1(9),T9$(30,
   11)4,Z9(20),Z8(20),B1(10)
40 REM STK GROUP CROSS SECTION = C
50 C=9.
60 C9=1.
70 REM CMFLG FACTOR USED IN BURNTHRU
80 Y8=300.
90 X9=300.
100 REM SET LIMITS TO BEGIN GEOGRAPHIC SEARCH LIMIT
110 PRINT  "FOR ALL QUESTIONS: ENTER 1 FOR YES, 0 FOR NO."
120 INPUT  "DO YOU WISH TO CONSIDER A PARTICULAR MSN PROFILE
    AT THIS TIME?",M7
130 IF M7=0 THEN 150
140 INPUT  "WHICH MISSION? 1=ESCORT, 2=MOD ESCORT, 3=STANDOF
    F",M7
150 INPUT  "DO YOU HAVE A STRIKE ROUTE AT THIS TIME?",L8
160 IF L8=1 THEN 310
170 N=2:REM NO ROUTE YET USE APPROX. POINT
180 INPUT  "ENTER APPROX. STARTING LAT,LONG",Y1(1),X1(1)
190 INPUT  "ENTER TARGET LAT,LONG",Y1(2),X1(2)
200 FOR I=1 TO 2
210 Z8(I)=X1(I)
220 Z9(I)=Y1(I)
230 NEXT I
240 Z1=2
250 GOSUB '200:REM CONVERT DEG AND MIN TO DEG AND TENTHS
260 FOR I=1 TO 2
270 X1(I)=Z8(I)
280 Y1(I)=Z9(I)
290 NEXT I
300 GOTO 510
310 INPUT  "ENTER NUMBER OF TURNPTS.",N
320 M=N-1
330 FOR I=1 TO N:REM READ IN TURNPT. LAT,LONG
340 PRINT  "ENTER LAT,LONG OF TURNPT.";I
350 INPUT Y1(I),X1(I)
360 Z8(I)=X1(I)
370 Z9(I)=Y1(I)
380 NEXT I
390 Z1=N
400 GOSUB '200:REM CONVERT DEG AND MIN TO DEG AND TENTHS
410 FOR I=1 TO N
420 X1(I)=Z8(I)
430 Y1(I)=Z9(I)
440 NEXT I
450 INPUT  "ENTER MAG VAR., + FOR WEST, - FOR EAST",V
460 FOR I=1 TO M :REM ENTER TAS EACH LEG
470 PRINT  "ENTER TAS FOR EACH LEG.";I
480 INPUT  I1(I)
490 S3(I)=I1(I)/60. :REM NM PER MINUTE
500 NEXT I
510 FOR I=1 TO N
520 Z9(I)=X1(I)
530 NEXT I
540 Z1=N
550 GOSUB '215
560 F=Z2
```

```
570  GOSUB '215
580  F9=Z2
590  FOR I=1 TO N
600  Z9(I)=Y1(I)
610  NEXT I
620  Z1=N
630  GOSUB '210
640  T=Z2
650  GOSUB '215
660  B9=Z2
670  T=T+2.
680  B9=B9-2.
690  F=F+2.
700  F9=F9-2.
900  FOR I=1 TO N
910  Z8(I)=S1(I)
920  Z9(I)=S2(I)
930  NEXT I
940  Z1=K
950  GOSUB '200 : REM CONVERT DEG AND MIN TO DEG AND TENTHS
960  FOR I=1 TO K
970  S1(I)=Z8(I)
980  S2(I)=Z9(I)
990  NEXT I
1000  IF L8=0 THEN 1340
1010  IF M7=0 THEN 1340
1020  ON M7 GOTO 1340,1030,1250
1030  INPUT "DO YOU HAVE A MOD ESCORT ROUTE TO ENTER NOW?",M6
1040  IF M6=0 THEN 1340
1050  INPUT  "ENTER NUMBER OF TURNPOINTS IN MOD ESCORT ROUTE.
      ",M9
1060  FOR I=1 TO M9
1070  PRINT  "ENTER LAT,LONG FOR TURNPOINT.",I
1080  INPUT  Y2(I),X2(I)
1090  Z8(I)=X2(I)
1100  Z9(I)=Y2(I)
1110  NEXT I
1120  Z1=M9
1130  GOSUB '200: REM CONVERT DEG AND MIN TO DEG AND TENTHS
1140  FOR I=1 TO M9
1150  X2(I)=Z8(I)
1160  Y2(I)=Z9(I)
1170  NEXT I
1180  M8=M9-1
1190  FOR I=1 TO M8
1200  PRINT  "ENTER TAS FOR LEG.",I
1210  INPUT  M2(I)
1220  S5(I)=M2(I)/60.
1230  NEXT I
1240  GOTO 1340
1250  INPUT "DO YOU HAVE A STANDOFF PT. TO CONSIDER YET?",L5
1260  IF L5=0 THEN 1340
1270  INPUT  "ENTER LAT,LONG OF STANDOFF POINT.",S8,S9
1280  Z8(I)=S9
1290  Z9(I)=S8
1300  Z1=1
1310  GOSUB '200: REM CONVERT DEG AND MIN TO DEG AND TENTHS
1320  S9=Z8(I)
1330  S8=Z9(I)
1340  LOAD  DC F "MAIN2" 1341,6160
6170  INPUT  "ARE YOU THROUGH PLANNING?",L
6180  IF L=0 THEN 6550
6190  INPUT  "DO YOU WISH TO CONSIDER A DIFFERENT MISSION
      PROFILE?",L
6200  IF L=0 THEN 6220
6210  INPUT  "WHICH MISSION DO YOU WISH TO CONSIDER? 1=ESCORT
      2=MOD ESCORT, 3=STANDOFF.",M7
6220  INPUT  "DO YOU WISH TO CONSIDER ANOTHER STRIKE ROUTE?",
6220  INPUT  "DO YOU WISH TO CONSIDER ANOTHER STRK RTE?",L9
6230  IF L9=0 THEN 6440
6240  INPUT  "ENTER NUMBER OF TURNPOINTS.",N
6250  M=N-1
```

```
6260 FOR I=1 TO N: REM READ IN TURNPOINT LAT,LONG
6270 PRINT  "ENTER LAT,LONG OF TURNPOINT.";I
6280 INPUT  Y1(I),X1(I)
6290 Z8(I)=X1(I)
6300 Z9(I)=Y1(I)
6310 NEXT I
6320 Z1=N
6330 GOSUB '200: REM CONVERT DEG AND MIN TO DEG AND TENTHS
6340 FOR I=1 TO N
6350 X1(I)=Z8(I)
6360 Y1(I)=Z9(I)
6370 NEXT I
6380 FOR I=1 TO M: REM ENTER TAS EACH LEG
6390 PRINT  "ENTER TAS FOR EACH LEG.";I
6400 INPUT  I1(I)
6410 S3(I)=I1(I)/609  : REM N.M. PER MINUTE
6420 NEXT I
6430 L8=1
6440 ON M7 GOTO 6540,1030,6450
6450 INPUT  "DO YOU WANT TO CONSIDER ANOTHER STANDOFF POINT?
     ",L5
6460 IF L5=0 THEN 6170
6470 INPUT  "ENTER LAT,LONG OF STANDOFF POINT.",S8,S9
6480 Z8(I)=S9
6490 Z9(I)=S8
6500 Z1=1
6510 GOSUB '200: REM CONVERT DEG AND MIN TO DEG AND TENTHS
6520 S9=Z8(I)
6530 S8=Z9(I)
6540 V7=999
6541 LOAD  DC F "MAIN2"
6550 STOP
6560 DEFFN'246 : REM  RADN  THIS SUBROUTINE CONVERTS TRUE
     HDG FROM DEGREES TO RADIANS FOR USE IN COMPUTING THE
     DISTANCE INCREMENT OF LAT,LONG IN THE TIME SCENARIO.
6570 Z1=2.*#PI/360.
6580 IF N2(I)GE.0 THEN 6610
6590 H=(450-N2(I))*Z1
6600 RETURN
6610 IF N2(I) LE. 90 THEN 6630
6620 GOTO 6590
6630 H=(90-N2(I))*Z1
6640 RETURN
6650 DEFFN'248 : REM SAME AS '246
6660 Z1=2.*#PI/360.
6670 IF N3(J) GE. 0 THEN 6700
6680 H=(450-N3(4))*Z1
6690 RETURN
6700 IF N3(J) LE. 90 THEN 6720
6710 GOTO 6680
6720 H=(90-N3(J))*Z1
6730 RETURN
6740 DEFFN'225 : REM  TD  THIS SUBROUTINE COMPUTES THE TIME
     AND DISTANCE AROUND A PARTICULAR ROUTE, BOTH TOTAL AND
     INDIVIDUAL LEG VALUES.
6750 Z2=0.
6760 Z1=0.
6770 FOR I=1 TO M : REM MUST CALCULATE A SCALEDOWN FACTOR,Z3
     , BECAUSE LAT NE. TO LONG IN DISTANCE.
6780 Z3=1.0294-.0023*ABS((Y1(I+1)+Y1(I))/2.)-.0001*((Y1(I+1)
     +Y1(I))/2.) 2
6790 Z4=(X1(I+1)-X1(I))*Z3
6800 Z5=Y1(I+1)-Y1(I)
6810 D1(I)=SQR(Z4 2+Z5 2)
6820 D1(I)=D1(I)*60.
6830 Z2=Z2+D1(I)
6840 D4(I)=Z2
6850 T3(I)=D1(I)/S3(I)
6860 Z1=Z1+T3(I)
6870 T2(I)=Z1
6880 NEXT I
6890 RETURN
```

```
6900 DEFFN'235 : REM  TD  SAME AS '225
6910 Z1=0.
6920 Z2=0.
6930 FOR I=1 TO M8 : REM CALCULATE SDF
6940 Z3=1.0294-.0023*ABS((Y2(I+1)+Y2(I))/2.)-.0001*((Y2(I+1)
     +Y2(I))/2.) 2
6950 Z4=(X2(I+1)-X2(I))*Z3
6960 Z5=Y2(I+1)-Y2(I)
6970 D2(I)=SQR(Z4 2+Z5 2)
6980 D2(I)=D2(I)*60.
6990 Z2=Z2+D2(I)
7000 D3(I)=Z2
7010 T6(I)=D2(I)/S5(I)
7020 Z1=Z1+T6(I)
7030 T5(I)=Z1
7040 NEXT I
7050 RETURN
7060 DEFFN'210 : REM  MAX  THIS SUBROUTINE IS USED TO FIND
     THE MAX VALUE OF A LIST PASSED TO IT.
7070 Z2=Z9(I)
7080 FOR I=2 TO Z1
7090 IF Z9(I) LE. Z2 THEN 7110
7100 Z2=Z9(I)
7110 NEXT I
7120 RETURN
7130 DEFFN'215 : REM  MIN  THIS SUBROUTINE IS USED TO FIND
     THE MIN VALUE OF A LIST PASSED TO IT.
7140 Z2=Z9(I)
7150 FOR I=2 TO Z1
7160 IF Z9(I) GE. Z2 THEN 7180
7170 Z2=Z9(I)
7180 NEXT I
7190 RETURN
7200 DEFFN'220 : REM SCALE  THIS SUBROUTNE TAKES THE MIN AND
     MAX VALUES OF X AND Y COORDS, AND ADJUSTS TO MAKE PLOT
     ON GRAPH ALWAYS SQUARE.
7210 Z1=ABS(X6-X9)
7220 Z2=ABS(Y9-Y8)
7230 IF Z1 GE. Z2 THEN 7280
7240 Z3=X9+(Z1/2.)
7250 X9=Z3-(Z2/2.)
7260 X6=Z3+(Z2/2.)
7270 GOTO 7310
7280 Z4=Y8+(Z2/2.)
7290 Y8=Z4-(Z1/2.)
7300 Y9=Z4+(Z1/2.)
7310 RETURN
7320 DEFFN'230 : REM  HDG  THIS SUBROUTINE COMPUTES TRUE AND
     MAG HDG FOR A ROUTE OF FLIGHT.
7330 Z1=180./#PI
7340 FOR I=1 TO M : REM MUST CALCULATE SDF (Z2) SINCE LAT
     NOT EQUAL TO LONG IN DIST.
7350 Z2=1.0294-.0023*ABS((Y1(I+1)+Y1(I))/2.)-.0001*((Y1(I+1)
     +Y1(I))/2.) 2
7360 Z3=(X1(I+1)-X1(I))*Z2
7370 Z4=Y1(I+1)-Y1(I)
7380 Z5=ARCTAN(Z4/Z3)
7390 IF Z3 GE. 0. THEN 7420
7400 Z5=(1.5*#PI-Z5)*Z1
7410 GOTO 7430
7420 Z5=(#PI/2.-Z5)*Z1
7430 N2(I)=Z5+.5
7440 M3(I)=N2(I)+V
7450 Z6=M3(I)
7460 IF Z6 GE. 0. THEN 7490
7470 M3(I)=M3(I)+360.
7480 GOTO 7510
7490 IF Z6 LT. 360. THEN 7510
7500 M3(I)=M3(I)-360.
7510 NEXT I
7520 RETURN
7530 DEFFN'240 : REM CALCULATE SDF (Z2)
```

```
7540 Z1=180./#PI
7550 FOR I=1 TO M8 : REM CALCULATE SDF (Z2).
7560 Z2=1.0294-.0023*ABS((Y2(I+1)+Y2(I))/2.)-.0001*((Y2(I+1)
     +Y2(I))/2.) 2
7570 Z3=(X2(I+1)-X2(I))*Z2
7580 Z4=Y2(I+1)-Y2(I)
7590 Z5=ARCTAN(Z4/Z3)
7600 IF Z3 GE. 0. THEN 7630
7610 Z5=(1.5*#PI-Z5)*Z1
7620 GOTO 7640
7630 Z5=(#PI/2.-Z5)*Z1
7640 N3(I)=Z5+.5
7650 M1(I)=N3(I)+V
7660 Z6=M1(I)
7670 IF Z6 GE. 0. THEN 7700
7680 M1(I)=M1(I)+360.
7690 GOTO 7720
7700 IF Z6 LT. 360. THEN 7720
7710 M1(I)=M1(I)-360.
7720 NEXT I
7730 RETURN
7740 DEFFN'200 : REM  LL  THIS SUBROUTINE CONVERTS DEG AND
     MIN TO DEG AND TENTHS.
7750 FOR I=1 TO Z2
7760 Z2=Z8(I)
7770 Z3=Z8(I)-Z2
7780 Z3=Z3/.6
7790 Z8(I)=Z2+Z3
7800 Z4=Z9(I)
7810 Z5=Z9(I)-Z4
7820 Z5=Z5/.6
7830 Z9(I)=Z4+Z5
7840 NEXT I
7850 RETURN
7860 DEFFN'205 : REM RLL  THIS SUBROUTINE CONVERTS DEG AND
     TENTHS TO DEG AND MINS.
7870 FOR I=1 TO Z1
7880 Z2=Z8(I)
7890 Z3=Z8(I)-Z2
7900 Z3=Z3*.6
7910 Z8(I)=Z2+Z3
7920 Z4=Z9(I)
7930 Z5=Z9(I)-Z4
7940 Z5=Z5*.6
7950 Z9(I)=Z5+Z4
7960 NEXT I
7970 RETURN
```

PART TWO "MAIN2"

```
1341 IF V7=999 THEN 2420
1342 INPUT  "DO YOU WISH TO USE SHIP'S EOB?",L
1350 IF L=0 THEN 1550
1360 REM  NEXT SECTION USED FOR OBTAINING SHIP'S EOB
1550 INPUT  "DO YOU WISH TO ENTER SITES IN ADDITION TO OR
     INSTEAD OF FROM SHIP'S EOB?",L
1560 IF L=0 THEN 1640
1570 INPUT  "HOW MANY SITES ARE YOU ENTERING?",J
1580 N9=K+J
1590 K1=K+1
1600 FOR I=K1 TO N9
1610 INPUT  "ENTER LAT,LONG TYPE NO.",S2(I).S1N2),S6(I)
1620 NEXT I
1630 K=N9
1640 INPUT  "DO YOU WISH A LISTING OF THE EOB?",L
1650 IF L=0 THEN 2420
1660 FOR I=1 TO K
1670 Z8(I)=S1(I)
1680 Z9(I)=S2(I)
1690 NEXT I
1700 Z1=K
1710 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MIN.
1720 FOR I=1 TO K
1730 S1(I)=Z8(I)
1740 S2(I)=Z9(I)
1750 NEXT I
1760 PRINTUSING 1770
1770 % 1=ALL, 2=EW/ACQ, 3=TERM THREAT
1780 INPUT  "CHOOSE TYPE OF EMITTERS TO USE.",L
1790 ON L GOTO 1800,2030,2200
1800 FOR I=1 TO K : REM THIS LISTS ALL EMITTERS
1810 J=S6(I)
1820 IF I2 NE. 0 THEN 1850
1830 PRINTUSING 1840
1840 % MSN  BAND LIST RNGE FLO FHI PRF1 PRF1 PRF2 PRF2 AUTO
     DEGR PRCT
1850 I2=I2+1
1860 PRINT  "SITE";I;TAB(8);"L/L";S2(I);"/";S1(I)
1870 PRINT  TAB(2);T8$(J);TAB(17);T7$(J)
1880 PRINT  T9$(J,1);" ";B1(J);" ";T9$(J,2);" ";T1(J);" ";
     T9$(J,3);" ";T9$(J,4);" ";T9$(J,5);" ";T9$(J,6);" ";
     T9$(J,7);" ";T9$(J,8);" ";T9$(J,9);" ";T9$(J,10);" ";
     T9$(J,11)
1890 PRINT
1900 Z8(I)=S1(I)
1910 Z9(I)=S2(I)
1920 IF I2 NE. 3 THEN 1940
1930 I2=0
1940 NEXT I
1950 Z1=K
1960 GOSUB '200 : REM CONVERT DEG AND MIN TO DEG AND TENTHS.
1970 FOR I=1 TO K
1980 S1(I)=Z8(I)
1990 S2(I)=Z9(I)
2000 NEXT I
2010 GOTO 2420
2020 REM NEXT SECTION FOR EW/ACQ ONLY
2030 FOR I=1 TO K
2040 J=S6(I)
2050 IF J GT. 10 THEN 2170
2060 IF I2 NE. 0 THEN 2080
2070 PRINTUSING 1840
2080 I2=I2+1
2090 PRINT  "SITE ";I;TAB(8);"L/L ";S2(I);"/";S1(I);
2100 PRINT  TAB(2);T8$(J);TAB(17);T7$(J)
2110 PRINT  T9$(J,1);" ";B1(J);" ";T9$(J,2);" ";T1(J);" ";
     T9$(J,3);" ";T9$(J,4);" ";T9$(J,5);" ";T9$(J,6);" ";
     T9$(J,7);" ";T9$(J,8);" ";T9$(J,9);" ";T9$(J,10);" ";
```

```
     T9$(J,11)
2120 PRINT
2130 Z8(2)=S1(I)
2140 Z9(I)=S2(I)
2150 IF I2 NE. 3 THEN 2170
2160 I2=0
2170 NEXTI
2171 Z1=K
2172 GOSUB '200 : REM CONVERT DEG AND MIN TO DEG AND TENTHS.
2173 FOR I=1 TO K
2174 S1(I)=Z8(I)
2175 S2(I)=Z9(I)
2176 NEXTI
2180 GOTO 2420
2190 REM THIS SECTION LISTS TERM THREATS ONLY.
2200 FOR I=1 TO K
2210 J=S6(I)
2220 IF J LE. 10 THEN 2350
2230 IF J GT. 20 THEN 2350
2240 IF J NE. 0 THEN 2260
2250 PRINTUSING 1840
2260 I2=I2+1
2270 PRINT  "SITE ";I;TAB(8);"L/L ";S2(I);"/";S1(I);
2280 PRINT  TAB(2);T8$(J);TAB(17);T7$(J)
2290 PRINT  T9$(J,1);" ";B1(J);" ";T9$(J,2);" ";T1(J);" ";
     T9$(J,3);" ";T9$(J,4);" ";T9$(J,5);" ";T9$(J,6);" ";
     T9$(J,7);" ";T9$(J,8);" ";T9$(J,9);" ";T9$(J,10);" ";
     T9$(J,11)
2300 PRINT
2310 Z8(I)=S1(I)
2320 Z9(I)=S2(I)
2330 IF I2 NE. 3 THEN 2350
2340 I2=0
2350 NEXT I
2360 Z1=K
2370 GOSUB '200: REM CONVERT DEG AND MIN TO DEG AND TENTHS.
2380 FOR I=1 TO K
2390 S1(I)=Z8(I)
2400 S2(I)=Z9(I)
2410 REM NEXT SECTION TO DISPLAY INFO
2420 INPUT  "DO YOU WISH TO DISPLAY ECB AND ROUTE?",L7
2430 IF L7=0 THEN 3900
2440 PRINTUSING 1770
2450 INPUT  "CHOOSE TYPE OF EMITTER ENVELOPES FOR DISPLAY.",
     L6
2460 IF M7 NE. 3 THEN 2490
2470 INPUT  "DO YOU WANT TO SEE THE ENVELOPES DEPRESSED BY
     JAMMING?",J9
2480 REM THIS SECTION MAKES GEOGRAPHIC WINDOW.
2490 FOR I=1 TO N
2500 Z9(I)=X1(I)
2510 NEXT I
2520 Z1=N
2530 GOSUB '210
2540 X6=Z2
2550 GOSUB '215
2560 X9=Z2
2570 FOR I=1 TO K
2580 Z9(I)=S1(I)
2590 NEXT I
2600 Z1=K
2610 GOSUB '210
2620 IF X6 GT. Z2 THEN 2640
2630 X6=Z2
2640 X6=X6+.2
2650 GOSUB '215
2660 IF X9 LT. Z2 THEN 2680
2670 X9=Z2
2680 X9=X9-.2
2690 FOR I=2 TO N
2700 Z9(I)=Y1(I)
2710 NEXT I
```

```
2720 Z1=N
2730 GOSUB '210
2740 Y9=Z2
2750 GOSUB '215
2760 Y8=Z2
2770 FOR I=1 TO K
2780 Z9(I)=S2(I)
2790 NEXT I
2800 Z1=K
2810 GOSUB '210
2820 IF Y9 GT. Z2 THEN 2840
2830 Y9=Z2
2840 Y9=Y9+.2
2850 GOSUB '215
2860 IF Y8 LT. Z2 THEN 2880
2870 Y8=Z2
2880 Y8=Y8-.2
2890 GOSUB '220
2900 REM NEXT SECTION RESERVED FOR PLOTTER CODE
3900 LOAD DC F "MAIN3" 1341,6160
```

PART THREE "MAIN3"

```
3901 IF L8=0 THEN 6170 : REM NO ROUTE PREVIOUSLY PICKED.
3910 IF M7=0 THEN 6440 : REM NO MISSION PREVIOUSLY PICKED.
3920 GOSUB '225 : REM CALCULATE TIME AND DIST AROUND ROUTE.
3930 GOSUB '230 : REM CALCULATE HEADINGS AROUND ROUTE.
3940 INPUT  "DO YOU WANT A NAV SOLUTION? IT'S NECESSARY FOR
     A TIME SCENARIO ",L
3950 IF L=0 THEN 6170
3960 PRINTUSING 3970
3970 %  STRIKE GROUP NAVIGATION SOLUTION
3980 PRINT
3990 PRINTUSING 4000
4000 %  LEG   DIST  TIME   TH   MH  TAS   TOTT   TOTD
4010 FOR I=1 TO N
4020 Z8(I)=X1(I)
4030 Z9(I)=Y1(I)
4040 NEXT I
4050 Z1=N
4060 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
4070 FOR I=1 TO N
4080 X1(I)=Z8(I)
4090 Y1(I)=Z9(I)
4100 NEXT I
4110 FOR I=1 TO M
4120 PRINT  TAB(2);I;TAB(7);D1(I);TAB(13);T3(I);TAB(20);
     N2(I);TAB(25);M3(I);TAB(29);I1(I);TAB(35);T2(I);TAB(42)
     ;D4(I)
4130 PRINT "FROM ";Y1(I);"/";X1(I);"TO ";Y1(I+1);"/";X1(I+1)
4140 PRINT
4150 NEXT I
4160 FOR I=1 TO N
4170 Z8(I)=X1(I)
4180 Z9(I)=Y1(I)
4190 NEXT I
4200 Z1=N
4210 GOSUB '200 : REM CONVERT DEG AND MIN TO DEG AND TENTHS.
4220 FOR I=1 TO N
4230 X1(I)=Z8(I)
4240 Y1(I)=Z9(I)
4250 NEXT I
4260 ON M7 GOTO 4590,4280,5261
4270 REM HAVE TO CALCULATE A NAVIGATION SOLUTION FOR THE
     EA6B IF MOD ESCORT MISSION, THEN TIME SCENARIO
4280 GOSUB '235
4290 GOSUB '240
4300 FOR I=1 TO M7
4310 Z8(I)=X2(I)
4320 Z9(I)=Y2(I)
4330 NEXT I
4340 Z1=M7
4350 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
4360 FOR I=1 TO M7
4370 X2(I)=Z8(I)
4380 Y2(I)=Z9(I)
4390 NEXTI
4400 PRINT  "   MOD ESCORT NAVIGATION SOLUTION."
4410 PRINT
4420 PRINTUSING 4000
4430 FOR I=1 TO M8
4440 PRINT  TAB(2);I;TAB(7);D2(I);TAB(13);T6(I);TAB(20);
     N3(I);TAB(25);M1(I);TAB(29);M2(I);TAB(35);T5(I);TAB(42)
     ;D3(I)
4450 PRINT  "FROM ";Y2(I);"/";X2(I);"/";" TO ";Y2(I+1);"/";
     X2(I+1)
4460 PRINT
4470 NEXT I
4480 FOR I=1 TO M9
4490 Z8(I)=X2(I)
4500 Z9(I)=Y2(I)
```

```
4510 NEXT I
4520 Z1=M9
4530 GOSUB '200 : REM CONVERT DEG AND MIN TO DEG AND TENTHS.
4540 FOR I=1 TO M9
4550 X2(I)=Z8(I)
4560 Y2(I)=Z9(I)
4570 NEXT I
4580 REM NEXT SECTION BEGINS TIME SCENARIO.
4590 INPUT  "DO YOU WANT A TIME SCENARIO?",L
4600 IF L=0 THEN 6170
4610 PRINT  "HOW MANY BANDS DO YOU WANT TO CONSIDER?"
4620 INPUT  "NO COMBOS, 5/6 COUNTS AS 2.",N8
4630 PRINT  "ENETR BANDS, ONE AT A TIME."
4640 FOR I=1 TO N8
4650 INPUT N1(I)
4660 NEXTI
4670 PRINT  "WHICH TYPE OF EMITTERS ARE YOU INTERESTED IN
      FOR THOSE BANDS?"
4680 INPUT  "1=ALL, 2=EW/ACQ ONLY, 3=TERM THREAT ONLY.",N7
4690 REM PRINT OUT HEADINGS FOR TIME SCENARIO.
4700 PRINT  "  TIME   PRES POS     TYPE ECB  RNGE BRG AUTO
     DEGR PERCT"
4710 REM SET INITIAL CONDITIONS FOR THE TIME SOLUTION.
4720 IF M7=2 THEN 5260
4730 S7=0.
4740 P8=X1(I)
4750 P9=Y1(I)
4760 Z8(I)=P8
4770 Z9(I)=P9
4780 Z1=1
4790 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
4800 P8=Z8(I)
4810 P9=Z9(I)
4820 PRINT  S7;P9;"/";P8
4830 Z8(I)=P8
4840 Z9(I)=P9
4850 Z1=1
4860 GOSUB '200 : REM CONVERT DEG AND MINS TO DEG AND TENTHS
4870 P8=Z8(I)
4880 P9=Z9(I)
4890 GOSUB '245 : REM NOW PROCEED AROUND THE ROUTE AT ONE
     MINUTE INTERVALS.
4900 I=1
4910 S7=S7+1.
4920 D9=S3(I)/60.
4930 IF T2(I) GT. S7 THEN 5070 : REM NOT TRUE MEANS TP WAS
     LE. ONE MINUTE FROM LAST COMPUTED POSITION.
4940 P7=S7-T2(I)
4950 I=I+1  : REM IS THIS THE LAST TURNPOINT?
4960 IF I=N THEN 5030
4970 P8=X1(I)
4980 P9=Y1(I)
4990 GOSUB '246 : REM CONVERT DEG TO RADNS.
5000 P8=P8+P7*S3(I)/60.*COS(H)
5010 P9=P9+P7*S3(I)/60.*SIN(H)
5020 GOTO 5100 : REM IT WAS THE LAST TURNPOINT.
5030 P8=X1(N)
5040 P9=Y1(N)
5050 S7=T2(M)
5060 GOTO 5100 : REM NEXT SECTION MEANS HAVE NOT GONE PAST A
     TURNPOINT, JUST INCREMENT FOR THIS LEG AND CONTINUE.
5070 GOSUB '246 : REM CONVERT DEG TO RADNS.
5080 P8=P8+D9*COS(H)
5090 P9=P9+D9*SIN(H)
5100 Z8(I)=P8
5110 Z9(I)=P9
5120 Z1=1
5130 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
5140 P8=Z8(1)
5150 P9=Z9(1)
5160 PRINT S7;P9;"/";P8
5170 Z8(1)=P8
```

```
5180 Z9(1)=P9
5190 Z1=1
5200 GOSUB '200 : REM CONVERT DEG AND MINS TO DEG AND TENTHS
5210 P8=Z8(1)
5220 P9=Z9(1)
5230 GOSUB '245
5240 IF S7 GE. T2(M) THEN 6170
5250 GOTO 4910
5260 LOAD DC F "MAIN4"
5261 V8=999
5262 LOAD DC F "MAIN4"
```

PART FOUR "MAIN4"

```
5263 IF V8=999 THEN 5290
5264 S7=0.
5270 P8=X2(1)
5280 P9=Y2(1)
5290 X7=X1(1)
5300 Y6=Y1(1)
5310 Z8(1)=P8
5320 Z9(1)=P9
5330 Z1=1
5340 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
5350 P8=Z8(1)
5360 P9=Z9(1)
5370 PRINT  S7;P9;"/";P8
5380 Z8(1)=P8
5390 Z9(1)=P9
5400 Z1=1
5410 GOSUB '200 : REM CONVERT DEG AND MINS TO DEG AND TENTHS
5420 P8=Z8(1)
5430 P9=Z9(1)
5440 GOSUB '245
5450 I=1
5460 J=1
5470 S7=S7+1.
5480 D9=S3(I)/60.
5490 D8=S5(I)/60.
5500 IF T2(I) GT. S7 THEN 5630
5510 P7=S7-T2(I)
5520 I=I+1.
5530 IF I=N THEN 5600
5540 X7=X1(I)
5550 Y6=Y1(I)
5560 GOSUB '246 : REM CONVERT THDG TO RADN.
5570 X7=X7+P7*S3(I)/60.*COS(H)
5580 Y6=Y6+P7*S3(I)/60.*SIN(H)
5590 GOTO 5660
5600 X7=X1(N)
5610 Y6=Y1(N)
5620 GOTO 5660
5630 GOSUB '246 : REM CONVERT THDG TO RADN.
5640 X7=X7+D9*COS(H)
5650 Y6=Y6+D9*SIN(H)
5660 IF T5(J) GT. S7 THEN 5790
5670 P7=S7-T5(J)
5680 J=J+1
5690 IF J=M9 THEN 5760
5700 P8=X2(J)
5710 P9=Y2(J)
5720 GOSUB '248 : REM CONVERT THDG TO RADN.
5730 P8=P8+P7*S5(J)/60.*COS(H)
5740 P9=P9+P7*S5(J)/60.*SIN(H)
5750 GOTO 5820
5760 P8=X2(M9)
5770 P9=Y2(M9)
5780 GOTO 5820
5790 GOSUB '248 : REM CONVERT THDG TO RADN.
5800 P8=P8+D8*COS(H)
5810 P9=P9+D8*SIN(H)
5820 Z8(1)=P8
5830 Z9(1)=P9
5840 Z1=1
5850 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
5860 P8=Z8(1)
5870 P9=Z9(1)
5880 PRINT  S7;P9;"/";P8
5890 GOSUB '245
5900 IF S7 GT. T5(M8) THEN 6170
5910 GOTO 5470
5920 INPUT  "DO YOU WANT A PRINTOUT OF JAMMING PARAMETERS
```

```
     FOR THIS STANDOFF POINT?",L
5930 IF L=0 THEN 6170
5940 PRINT  "HOW MANY BANDS DO YOU WANT TO CONSIDER?"
5950 INPUT  "NO COMBOS, 5/6 COUNTS AS 2.",N8
5960 PRINT  "ENTER BANDS, ONE AT A TIME."
5970 FOR I=1 TO N8
5980 INPUT N1(I)
5990 NEXT I
6000 PRINT  "WHICH TYPE OF EMITTERS ARE YOU INTERESTED IN
     FOR THOSE BANDS?"
6010 INPUT  "1=ALL, 2=EW/ACQ ONLY, 3"TERM THREAT ONLY.",N7
6020 PRINT "STANDOFF L/L TYPE EOB RNGE BRG AUTO DEGR PERCT"
6030 Z8(1)=S9
6040 Z9(1)=S8
6050 Z1=1
6060 GOSUB '205:REM RECONVERT DEG AND TENTHS TO DEG AND MINS
6070 S9=Z8(1)
6080 S8=Z9(1)
6090 PRINT  S8;"/";S9
6100 Z8(1)=S9
6110 Z9(1)=S8
6120 Z1=1
6130 GOSUB '200 : REM CONVERT DEG AND MINS TO DEG AND TENTHS
6140 S9=Z8(1)
6150 S8=Z9(1)
6160 GOSUB '245
```

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